Super Ball Bot - Structures for Planetary Landing and Exploration

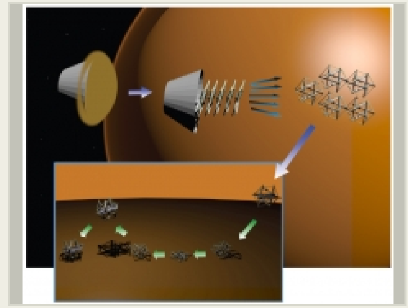
Completed Technology Project (2013 - 2015)

Project Introduction

Small, light-weight and low-cost missions will become increasingly important to NASA's exploration goals. Ideally teams of small, collapsible robots, weighing only a few kilograms apiece, will be conveniently packed during launch and would reliably separate and unpack at their destination. Such robots will allow rapid, reliable in-situ exploration of hazardous destination such as Titan, where imprecise terrain knowledge and unstable precipitation cycles make single-robot exploration problematic. Unfortunately landing lightweight conventional robots is difficult with current technology. Current robot designs are delicate, requiring a complex combination of devices such as parachutes, retrorockets and impact balloons to minimize impact forces and to place a robot in a proper orientation. Instead, we are developing a radically different robot based on a "tensegrity" built purely upon tensile and compression elements. Such robots can be both a landing and a mobility platform allowing for a dramatically simpler mission profile and reduced costs. These multi-purpose robots can be light-weight, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and are easy to collapse and uncollapse. These properties allow for unique mission profiles that can be carried out with low cost and high reliability. We believe tensegrity robot technology can play a critical role in future planetary exploration.

Anticipated Benefits

Small, light-weight and low-cost missions will become increasingly important to NASA's exploration goals. Ideally teams of small, collapsible, light weight robots, will be conveniently packed during launch and would reliably separate and unpack at their destination. Such robots will allow rapid, reliable in-situ exploration of hazardous destination such as Titan, where imprecise terrain knowledge and unstable precipitation cycles make single-robot exploration problematic. We are developing a radically different robot based on a tensegrity structure and built purely with tensile and compression elements. Such robots can be both a landing and a mobility platform allowing for dramatically simpler mission profile and reduced costs. These multi-purpose robots can be light-weight, compactly stored and deployed, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and can provide surface mobility. These properties allow for unique mission profiles that can be carried out with low cost and high reliability, and which minimizes the inefficient dependance on use once and discard mass associated with traditional landing systems. We believe tensegrity robot technology can play a critical role in future planetary exploration.



Project Image Super Ball Bot - Structures for Planetary Landing and Exploration

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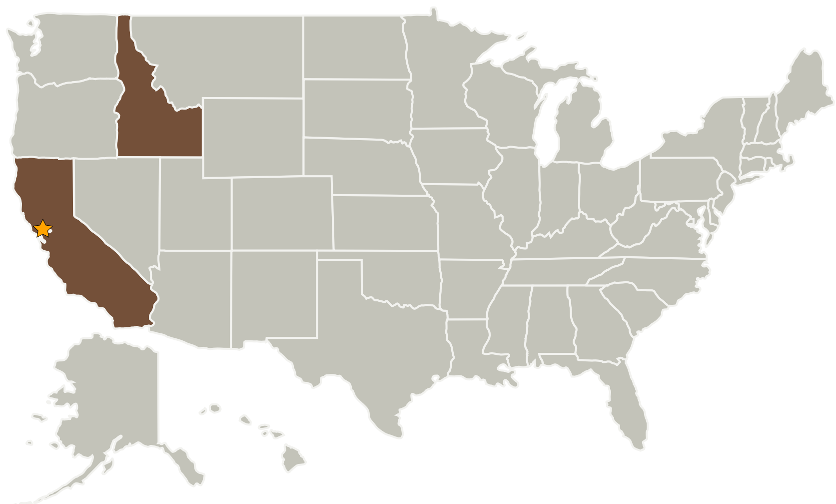

Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
University of Idaho	Supporting Organization	Academia	Moscow, Idaho

Primary U.S. Work Locations	
California	Idaho

Project Transitions

September 2013: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

Eric A Eberly

Principal Investigator:

Vytas Sunspiral

Co-Investigator:

Adrian K Agogino

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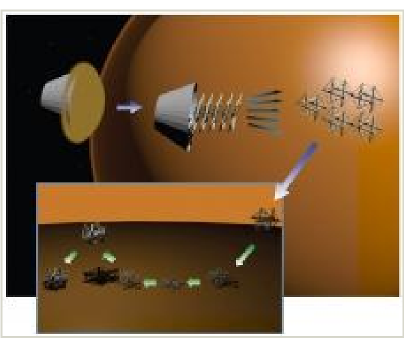
September 2015: Closed out

Closeout Summary: Small, light-weight and low-cost missions will become increasingly important to NASA's exploration goals. Ideally teams of small, collapsible, light weight robots, will be conveniently packed during launch and would reliably separate and unpack at their destination. Such robots will allow rapid, reliable in-situ exploration of hazardous destination such as Titan, where imprecise terrain knowledge and unstable precipitation cycles make single-robot exploration problematic. Unfortunately landing lightweight conventional robots is difficult with current technology. Current robot designs are delicate, requiring a complex combination of devices such as parachutes, retrorockets and impact balloons to minimize impact forces and to place a robot in a proper orientation. Instead we are developing a radically different robot based on a tensegrity structure and built purely with tensile and compression elements. Such robots can be both a landing and a mobility platform allowing for dramatically simpler mission profile and reduced costs. These multi-purpose robots can be light-weight, compactly stored and deployed, absorb strong impacts, are redundant against single-point failures, can recover from different landing orientations and can provide surface mobility. These properties allow for unique mission profiles that can be carried out with low cost and high reliability (see Figure 1), and which minimizes the inefficient dependance on use once and discard mass associated with traditional landing systems. We believe tensegrity robot technology can play a critical role in future planetary exploration. Our Phase II study explored: 1) Designing an untethered hardware prototype of a tensegrity robot ball. 2) Evolutionary and Central Pattern Generator based controls allowing for directed rolling, rolling over hills, rolling over obstacles and rolling up hill. 3) Modeling and verification of landing properties under a wide range of conditions.

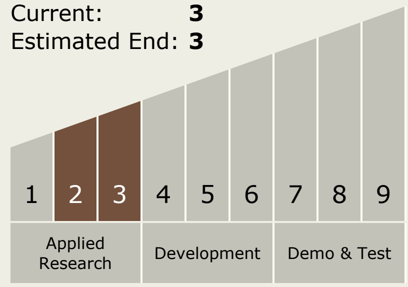
Images



13751-1390593700500.jpg
Project Image Super Ball Bot - Structures for Planetary Landing and Exploration *(https://techport.nasa.gov/image/102170)*

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX04 Robotic Systems
  └ TX04.2 Mobility
    └ TX04.2.1 Below-Surface Mobility

Target Destinations

The Moon, Mars

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html